VOLUMETRIC EFFICIENCY AND FUEL TRIM ANALYSIS

TESTING A MAF SENSOR

A defective MAF sensor can cause transmission shifting issues and eventual failure. Usually long soft shifts and flares due to improper pressure rise. This is usually followed by clutch failure such as the 3-4 clutch in the 4L60E. Sometimes the transmission can have late shifts due to the driver stepping on the throttle harder to make up for the poor engine performance. A good test for a MAF sensor is comparing Volumetric Efficiency and Fuel Trims.

Connect a scan tool and set it to record or take a movie of the following data (PIDS). Engine RPM, Mass Air Flow (MAF) in grams per second, Intake Air Temp (IAT), in degrees F, Long Term Fuel Trim (LTFT) and Barometric Pressure (BARO) in (kPa) or Manifold Absolute Pressure (MAP) in kilopascals (kPa). It would also be useful to capture the Oxygen sensors (HEGO). (B1S1) and (B2S1).

With the engine at operating temperature, accelerate from a standing stop, then depress the accelerator to Wide Open Throttle (WOT). You need to be at WOT while the transmission is still in first gear. Hold WOT until the transmission makes a 1-2 upshift. The goal is to record the above data when the engine is at maximum RPM which will happen just before the 1-2 upshift. Note: you may want to perform the test two or three times and use the data from the movie with the highest RPM and MAF readings.

Input the data into a VE calculator. These can be found online. Two popular ones are from otctools.com/ve and the other is from atgtraining.com/atg-volumetric-efficiency-calculator/. The one from otctools is the easiest to use and only requires four inputs, RPM, IAT, MAF and Engine size. The one from ATG also wants MAP or BARO readings but gives back more information. Note: The MAP or BARO reading only matters on boosted engines i.e Turbo or higher altitudes.

VE varies with different manufacturers, models, years and engine sizes. A good basic rule of thumb is that VE should be between 75% and 95% on a normally aspirated engine. Turbo or boosted engines may be above 100%. Important: 75% is the minimum acceptable number.

Analyze the Data. VE is a measurement of the engine's ability to breath. Air intake and exhaust.
If VE is below 75%, this indicates an engine breathing problem or faulty readings from the MAF. To determine if this is an actual breathing problem or MAF problem (fake breathing problem), look at the fuel trim data. If fuel trim goes positive, above 10%, this indicates a faulty MAF reading. If the intake duct is not disconnected or torn, then the MAF sensor is dirty, contaminated, or faulty.
The theory behind this is that the engine is breathing normally but the MAF is telling the PCM that air flow is low. Since the PCM believes the MAF, it delivers low fuel to go with the perceived low air flow. The low fuel shows up as a lean reading on the 02 sensor and the computer compensates for that by adding short term fuel followed by long term fuel. STFT will go positive then LTFT will go positive.
Bad MAF summary: VE below 75%, fuel trims go positive and 02 sensor(s) read lean
If the Fuel Trim stays within spec (below 10%) and the oxygen sensors read normal (Stays rich) at WOT, this indicates an actual engine breathing problem. Restricted intake or exhaust. In other words, the computer sees actual low air flow and delivers proper fuel for that low air flow.

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To determine if the restriction is on the intake or exhaust side, compare the MAP and BARO readings at WOT. Note, not all vehicles have MAP and BARO sensors. If you don't have a BARO sensor, use 101.32 as the BARO reading. This reading is for sea level.

At WOT, the throttle blade will be wide open. Engine vacuum will drop close to zero. Atmospheric pressure will be filling the engine. With that in mind, the MAP reading and BARO reading will be nearly the same at WOT. This would indicate a restricted exhaust system. Further testing such as exhaust back pressure should be done following manufacturers procedures. This can also be done with an in-cylinder pressure transducer.

If the MAP sensor reading moves away from the BARO reading as engine RPM increases, this indicates a restricted intake such as dirty air filter or other restrictions on the intake side. This is because the intake restriction acts like a partially closed throttle blade and the engine will still have vacuum. If no restrictions can be found, then it indicates cam and valve timing problems. Best test at this point is a running compression test from an in-cylinder pressure transducer.

If VE is at or above 75%, this would indicate no restrictions in the intake or exhaust system. The MAF is not faulty and intake/exhaust is not restricted. If this engine has a performance problem, it is most likely a fuel or ignition problem.

To diagnose further: Read fuel trim data and oxygen if you have it. Normal oxygen sensor readings will cycle rich and lean. Rich must go above .8 volts and lean must go below .2 volts. During WOT, a normal reading will be full rich or stay above .8 volts. Some vehicles may not stay at full rich but the important point is that they do not go lean at WOT.

The fuel trim data to look at will be normal driving and WOT. For most vehicles the short term fuel trim (STFT) should be within + or – 7% and long term fuel trim (LTFT) between + or – 10%. Note: Many European vehicles must keep LTFT at + or – 5%.

If the oxygen sensors go rich at WOT and the fuel trim is within specs then the vehicle does not have a low fuel delivery issue. If you have a performance problem at this point check for secondary ignition problems. (spark plugs, wires, coils, etc.)

If the oxygen sensor reads lean at WOT and LTFT is above 10%, this engine has low fuel delivery. Possible causes include weak fuel pump, restricted fuel filter or restricted fuel injectors. Further testing is required starting with fuel pressure. Low fuel summary: VE above 75%, Oxygen sensors read lean at WOT, Fuel trim goes positive above 10%

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PRINT OUT FORM

Step 1: Connect a scan tool and set it to record or take a movie of the following data (PIDS). Engine RPM, Mass Air Flow (MAF) in grams per second, Intake Air Temp (IAT) in degrees F, Long Term Fuel Trim (LTFT).

Step 2: With the engine at operating temperature, accelerate from a standing stop, then depress the accelerator to Wide Open Throttle (WOT). You need to be at WOT while the transmission is still in first gear. Hold WOT until the transmission makes a 1-2 upshift. The goal is to record the above data when the engine is at maximum RPM which will happen just before the 1-2 upshift.

Record your results: Engine RPM_____, Mass Air Flow (MAF) GPS _____, Intake Air Temp (IAT) _____, Long Term Fuel Trim (LTFT)_____.

Step 3: Input the data into a VE calculator such as the one at otctools.com/ve

Step 4: Analyze the Data. Is VE at or above 75%?

No, Go to step 5.____

Yes, Go to step 6.____

Step 5: Read long term fuel trim data. Is LTFT above 10%?_____
Yes, this indicates a dirty or faulty Mass Air Flow sensor (MAF). If the intake duct is not disconnected or torn, Replace the MAF sensor.

No, fuel trim is below 10%. This is an intake or exhaust restriction. The MAF is not faulty.

Step 6: The MAF is not faulty and intake/exhaust is not restricted.
If this engine has a performance problem, it is most likely a fuel or ignition problem.

Bad MAF summary: VE below 75%, and fuel trims go positive above 10%.